DOCUMENT RESUME

ED 306 122 SE 050 527

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TITLE Binary Number System Training for Graduate Foreign Students at New York Institute of Technology.
PUB DATE Feb 88
NOTE 141p.; M.S. Thesis, New York Insititute of Technology.
PUB TYPE Dissertations/Theses - Master Theses (042) -- Reports - Evaluative/Feasibility (142)

EDRS PRICE MF01/PC06 Plus Postage.
DESCRIPTORS *College Mathematics; *Computer Literacy; Foreign Students; Graduate Students; Higher Education; *Mathematical Concepts; Mathematical Logic; *Mathematics Achievement; Mathematics Curriculum; Mathematics Education; *Mathematics Instruction; Mathematics Materials
IDENTIFIERS *Binary Coding; Mathematics Education Research

ABSTRACT

This thesis describes the design, development, implementation, and evaluation of a training module to instruct graduate foreign students to learn the representation of the binary system and the method of decimal-binary conversion. The designer selected programmed instruction as the method of instruction and used the "lean" approach to develop the materials. The instructional book, designed specifically for non-computer background students who may have related work with computers was delivered to students at the New York Institute of Technology Metropolitan Center. Based on formative evaluation techniques, the instructional materials were tested and refined. Procedures were followed to ensure the validity and reliability of the materials. The final version of the book was successful--all students who failed the pre-test passed the posttest, and students had a positive attitude toward the program. The recommendations of the project include suggestions to extend the program content to addition, subtraction, multiplication and division in the binary system, as well as the inclusion of other number systems. Suggestions are also made to extend the learning process. Appendices included are: (1) "Project Planning"; (2) "Task Analysis"; (3) "Pretest"; (4) Post Test"; (5) "Instructional Materials"; (6) "Pre-Learning Questionnaire"; (7) "Post-Learning Questionnaire"; and (8) "Instructional Materials." (YP)

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BINARY NUMBER SYSTEM TRAINING FOR GRADUATE FOREIGN STUDENTS AT NEW YORK INSTITUTE OF TECHNOLOGY

a

THESIS/PROJECT

by

NUNTAWUN SUDSATAYA

submitted to the faculty of the

School of Media and Arts

of

NEW YORK INSTITUTE OF TECHNOLOGY

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

February 1988

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by

Nuntawun Sudsataya

A Thesis/Project

submitted to The Faculty of the

School Media and Arts

of The New York Institute of Technology in partial satisfaction of the requirements for the degree of

Master of Science

February 4, 1988

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ACKNOWLEDGEMENTS

This thesis/project is certainly the product of the assistance and encouragement of a number of people. I have many to thank for their energies on my behalf.

Dr. Angus Reynolds, Director and Professor of Training and Learning Technology, is my thesis/project advisor. He provided useful suggestions and support throughout the project.

Guy Sudsataya, Data Processing Analyst of Teachers Insurance, is a subject matter specialist. He provided guidelines, sources, and suggestions concerning the content of the project, binary number system.

I wish to thank my participants, NYIT graduate foreign students, who gave me the opportunity to test and refine the instructional materials. I especially appreciate Haruyo Ishibashi who provided the computer equipment to make this thesis/project possible.

My most important encouragement comes from my parents, sisters, and friends. Their understanding and support are all I can ask for.

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CHAPTER 1

INTRODUCTION

Overview

The binary number system is not a new subject. It was first used in the seventeenth century by Thomas Harriot (Halsey & Friedman, 1983). The binary number system has become a very important part in the field of computers because most computers in use today are designed to operate using the binary system. Therefore, information that is fed to the computers will be converted to the binary system.

A number system is a method of representing quantities of objects. It can be represented in many different ways. People are most familiar with the decimal number system. O'Malley (1972) stated that the popularity of the decimal system may have resulted from humans having ten fingers, but it is not necessarily superior to other number systems for calculations.

However, the binary system is best suited for computers because it requires components having only two different physical quantities "on" or "off", "flowing" or "not flowing", "0" or "1", and so on. The computer designers realized that utilizing the binary number system would result in a computer that is more reliable, has fewer components, is less expensive, smaller, and faster (O'Malley, 1972). On the other hand, the decimal system is not well suited for computers because it requires ten

different physical levels to represent the ten digits, 0 through 9.

Any number expressed in the binary system can also be expressed in the decimal system because there is a correspondence between the numbers in any system. The result of any calculation will lead to equivalent results as long as the basic rules of arithmetic are observed. Stein (1963) insisted that "any computation made in the binary system can be checked in the 'good old' decimal system" (p. 204). He also stated that if people learned only the binary system in grammar school and practiced its arithmetic for years, they would have difficulty if they had to deal with the decimal system (Stein, 1963).

The training program described in this thesis/project was focused only on the representation and conversion techniques of the binary number system. The completed course content of the binary system follows:

I. Structure and Number Representation

II. Binary - Decimal Conversion

III. Addition and Subtraction

IV. Multiplication and Division

Statement of the Problem

Computers play a significant part in almost everyone's daily life. However, people and computers do not use the

same language. People speak in words and use the decimal system to represent numbers, but computers operate in the binary system and are unable to understand human language. Since people and computers do not use the same language, methods of translating into a form which is understandable and usable to both are necessary (Naval Education and Training Program Development Center, 1979).

Therefore, to understand the working of a computer, people need to understand the binary system and the uses of it (Fuori, 1973). Smith (1967) insisted that the first skill that computer programmers or people who have related work must master is the ability to work with the binary system.

There are a variety of books and journals about the binary number system available in the market; however, most of those books and journals were written many years ago. Some of them are not suitable for students who do not have a good arithmetic background. Some are difficult to understand because they were designed specifically to serve the computer science or engineering student.

In recent years, there has been a growing demand to use computers to serve the needs of organizations as well as those of individuals because computers are able to take over routine jobs, releasing people for more important work that can not be handled by a computer. Furthermore, computers are now available to small businesses, students, and home users. These changes have influenced everyone's daily life.

The need for qualified employees is growing and applications of data processing are becoming extensive. It is obvious that the need for an introductory course that teaches concepts about the binary number system is appropriate because all computers are built as binary machines. Such a course will provide useful information for those who have an interest in the field of computers.

The designer decided to develop the binary number system training program because of her own experience in attending computer science classes. The instruction was not always clear and time was limited. The instructors assume that students understand the materials presented in the class. In fact, students need more time to practice, and sometimes more explanation. The designer also had an opportunity to discuss this matter with other students. The designer found that there are many students who do not understand the binary number system. Some of them, who use computers, are not aware of how a computer operates. Therefore, the designer decided to develop the training program to introduce the binary number system specifically to students who have no previous background but may have related work with computers.

Purpose of the Project

The purpose of the project described in this thesis/project was to develop a training program that

focused on the representation of the binary system and the method of decimal-binary conversion.

The project described in this thesis/project was to analyze, design, develop, implement, and evaluate a self-instructional book to enable foreign graduate students at New York Institute of Technology (NYIT) to learn the binary number system.

Definition of Terms

The terms or words that appeared in this thesis/project are the following:

Binary - Numbers are represented by the only two digits, 0 or 1 (Chandor, 1972).

Decimal - An integer represented by a single character in the range 0 - 9 (Chandor, 1972).

Lean Programming - This method was presented by Geary A. Rummler (1973). It is a method for developing instruction with the optimum amount of teaching material. It relies heavily on try out and revision (Brethower, 1976).

Pretest - The pretest is used for measuring those skills that are going to be taught in the instruction (Dick & Carey, 1985).

Post Test - The post test is parallel to and sometimes identical to the pretest. It measures the objectives taught in the instructional program (Dick & Carey, 1985).

Programmed Instruction - This is the method of presenting the subject matter in a series of small carefully graduated, sequential steps, so that the student achieves mastery of the material presented. This method allows students to proceed at their own pace (Nadler, 1982).

Assumptions

1. That knowledge of the binary number system is useful to graduate foreign students at a technology oriented institution such as NYIT.

2. That students can apply the basic understanding of a second (binary) number system and its conversion technique to learn yet other number systems (such as octal or hexadecimal).

Limitations

The project described in this thesis/project was developed at NYIT for use by graduate foreign students. The product may not be suitable for use in other types of organizations, circumstances, or countries.

Method and Procedures

The method used in developing the training program was based on the Instructional Systems Development (ISD) model described by Branson (1976), Craig (1976), Nadler (1982), and Dick & Carey (1985). Each educator broke down the ISD

model into different steps and several procedures. However, it can be analyzed and divided into five phrases: analysis, design, development, implementation, and evaluation.

Analysis

The designer reviewed the literature in order to gather the facts about the training need, and to ensure that it can be solved through training.

The training goal was identified, and a plan for the training development was established. The designer also surveyed existing courses, materials and professional literature in order to avoid duplication of effort. After the literature review had been completed, the task listing was developed. It helped to clarify the relationships and the sequence of presenting information.

Design

After the task listing had been developed, the designer made decisions about which tasks should be selected for training.

The next step was to determine the learning objectives. Mager (1984) suggested that each objective contains three characteristics:

1. Performance (what the learner is to be able to do)
2. Conditions (important conditions under which the performance is expected to occur)

3. Criterion (the quality or level of performance that will be considered acceptable) (Mager, 1984, p. 23)

These were incorporated in the project's objectives. The designer also determined the entry behaviors and sequenced objectives; planned learning activities; and specified a test system as well as training plan.

Development

The designer produced the learning events and activities based on the nine events of instruction described by Gagne (1985). The next step was to specify the method of instruction. The method of instruction used was programmed instruction as described by Garner (1966), Brethower (1976), and Wexley (1981).

The designer selected the instructional media and produced the material for evaluation. The method used for developing the instructional materials was based on the lean programming techniques described by Rummler (1973).

Implementation

The designer produced all the required materials, conducted the course according to the designed plan, and collected data for improvement of the course.

Evaluation

The evaluation was planned and conducted to determine the effectiveness of the course as well as the quality of

the instruction, and gather information from students. It provided the basis for accurate revision of the instruction.

Summary

Students need to learn the binary number system in order to understand the working of a computer. The self-instructional book developed in this project/thesis was written to serve NYIT graduate foreign students. The method of development was based on the ISD model. The teaching method was based on the programmed instruction and the development of instructional material was based on the lean programming.

CHAPTER 2

ANALYSIS

Introduction

Analysis is a technique used in examining the needs of organizations. It is considered to be the first critical event of designing and developing a training program. Without performing this step, designers or developers can not ensure that training will solve problems.

Definition of the Training Requirement

The designer analyzed the training needs, defined needs and analyzed the target population on the basis of knowledge gained from the following:

1. Review of the professional literature. In this review, the designer gathered information to answer the question, "Why there is a need to learn the binary number system?". The analysis showed that the need is a result from computers are designed to operate using the binary system.

2. Equipment. Computers are now playing a more significant part than they were. The demand to use computers for serving the needs of organizations and individual are growing. Therefore, a change in the equipment being used today can consider to be one of the sources that helps the designer ensure the training needs.

3. Experience and Observation. The designer found that many students at NYIT use computers and softwares (such as word processor) to do their assignment. Some of the students do not have a computer science background and are not aware of how a computer operates.

4. Survey of Existing Courses. Even though there are many books and journals available in the market, most of them were written a long time ago. Some are difficult to understand because they were designed to serve a certain group of population or to use technical terms. The survey showed that those existing courses are not appropriate to students who have a limited background in mathematics or computer science.

Definition of the Instructional Program

Instructional Goal

Students will use the group of binary digits (0 and 1) to write numbers in the binary system and demonstrate the technique of decimal-binary conversion.

Classify Instructional Goal

According to the domains of learning described by Gagne (1985), the instructional goal is classified as an intellectual skill. There are four types of intellectual skills: discriminations, concepts, rules, and problem solving. Students need to determine the difference between the decimal system and binary system; apply the rule of

representing the binary number and the decimal-binary conversion technique; and select the appropriate rules to solve problems.

Classification of the types of learning in the instructional program as suggested by Goad (1982) results in:

learning category = mental skill

learning subcategory = learning and using rules.

Use of the taxonomy of educational objectives suggested by Bloom (1956) classes the instructional program as "application".

Using the procedure outlined by Anderson (1983), it was determined that printed material was the media best suited to the instruction. The instructional program was planned as a self-instructional training program. Students were allowed to proceed at their own pace through the instructions without any required intervention from an instructor.

Budd (1987) stated that "Self-instruction is an all-inclusive term used to describe any teaching situation where students take responsibility for their own learning" (p. 489). She also reccommended a list of the most important factors that developers can use for designing their self-instructional program. The factors are the following:

- Good orientation program to the method
- Strong administrative support system

- Specification of objectives
- Frequent quizzes and practice
- Immediate feedback
- Mastery requirements to reach a specified performance standard
- Job-related performance requirements
- Procedures for review after original learning
- Self-pacing, or self-pacing within prescribed limits
- Systematic approach to content structure
- Empirical evaluation of materials (Budd, 1987, p. 492)

Survey of Existing Courses and Literature Review

The designer conducted the survey of existing courses in the topic of binary number system, number system, mathematics, and computer science from 1966 to 1987. After gathering information and listing of existing courses, the designer reviewed the contents and abstract of each course.

Survey of Existing Courses

The survey of existing courses was based on the research at NYIT and Mid-Manhattan Library. The designer also used the NYIT library service called TECHSEARCH. It is a computer-based bibliographic information system which makes the library resources available to students. It provides a bibliography and review of printed materials on a particular topic requested by a student.

The designer compared the existing courses with the instructional need that generated the project as described in this thesis/project. The designer found that seven out of twenty-six courses relate to the binary number system.

Literature Review

Resulting from the computer search, those seven courses are the following:

1. **Computer Numbering Systems and Binary Arithmetic** (Training Systems, Inc. and Stanley L. Levine, 1965)

This programmed text is a comprehensive course introducing students to computer number systems: decimal, binary, and octal. It explains how to convert from one system to another, as well as how to add, subtract, multiply, and divide in the binary system. This course is adaptable to self-study.

2. **How to Individualize Mathematics Successfully: with Materials for Implementation** (Mildred L. Vinskey, 1979)

Presented is a method for individualizing mathematics which utilizes the "Learning Activities Package" (LAP). LAP is a self-contained unit based on specific behavioral objectives which contains a pretest, a post test, examples, explanations, and activities. The topics include multiplication and division by powers of ten, squaring a number, binary numeration, using proportion to solve percent problems, simple interest, deposit slips and checks, how to read electric meter and check electric bill, and solving simple equations.

3. Introduction to the Computer (William M. Fuori, 1973)

This book is used by the beginning or advanced business student. It provides a basic understanding of what the computer is, what the computer can do, and how the computer can serve the users. It also provides detailed instruction on the four basic number systems: decimal, binary, octal, and hexadecimal.

4. Introduction to the Digital Computer (John O'Malley, 1972)

This book is suitable for students with good high school background. It presents topics in combinational switching circuits and digital computers including the number systems. The format of this book encourages self-study. It provides answers to students on their understanding of materials.

5. Switching and Finite Automata Theory (Zvi Kohavi, 1978)

The contents of this book deal with the representation of numerical data. The topic includes the representation of number system and conversion technique. This book is suitable for computer science and electrical engineering students. The readers need some technical background on mathematics.

6. Mathematics (David Bergamini, 1970)

This book concerns the ascent of mathematics, starting from simple counting to advanced methods as well as discussion on new mathematics that are taught in many schools.

7. Introduction to Number System, Boolean Algebra, Logic Circuits (Naval Education and Training Program Development Center, 1979)

This textbook was designed to provide information to the Navy personnel whose duties require an elementary and general knowledge of the fundamental concepts of number systems, logic circuits, and boolean algebra.

Plan for Design and Development Effort

The designer used time lines to indicate the events and activities of developing the training program from the beginning through the end. The process was started on February 9, 1987 and completed on May 11, 1987.

The designer also used the program evaluation and review technique (PERT) to plan the overall development of the self-instructional training program as described in this thesis/project. Levin and Kirkpatrick (1975) stated that "The PERT technique is a method of minimizing production delays, interruptions, and conflicts; of coordinating and synchronizing the various parts of the overall job; and of

expediting the completion of projects" (p. 489). PERT helped the designer to approach the completion of project on time.

PERT is concerned with two concepts:

1. **Events** - An event is a specific accomplishment that occurs at a recognizable point in time (Levin & Kirkpatrick, 1975).

2. **Activities** - An activity is the work required to complete a specific event (Levin & Kirkpatrick, 1975).

The project planning documents are shown in Appendix 1.

Summary

The designer identified the instructional goal. It is classified as an intellectual skill. Students used the intellectual skills (discriminations, concepts, rules, and problem solving) in the learning situation.

The program was planned to be a self-instructional program. The designer surveyed the existing courses and reviewed the professional literature. Plan for design and development effort was based on time lines and a PERT chart.

CHAPTER 3

DESIGN

Introduction

Design is the process of conducting an instructional task analysis to determine the knowledge and skills students would use when performing the job. The designer then identified the instructional objectives. These written statements define when, what, and how well students must perform. The designer also specified the entry behaviors and sequenced objectives. Learning activities were prepared for each task. Test and evaluation systems were planned. The design concludes with the review of existing materials.

Instructional Task Analysis

After the instructional goal was established and classified according to the domains of learning in the Analysis phase, the designer conducted an instructional task analysis to specify the major steps of learning that students will be doing when they are performing. These steps were then arranged in a logical order. The output from this process provides a broad overview of the completed task from beginning to end. It also provides the framework that the designer needed to identify the sub-tasks.

In this project, the major instructional tasks were divided into six steps. Each step was broken down into its subordinate skills. The technique used to identify the subordinate skills was to ask the question, "What does the

student need to know to learn each step?". The completed task analysis is presented in Appendix 2.

Instructional Objectives

The instructional objectives were derived from the instructional goal. The instructional objectives are called the terminal performance objectives (TPO).

Mager (1984) stated that "An objective is a description of a performance you want learners to be able to exhibit before you consider them competent. An objective describes an intended result of instruction, rather than the process of instruction itself" (p. 3).

Mager (1984) suggested that the format of an objective should include three characteristics: performance, conditions, and criterion (as described in Chapter 1).

The terminal performance objectives of the project described in this thesis/project are the following:

1. Given a written test, students will be able to write numbers in the binary system and its equivalence of decimal number with 90% accuracy.
2. Given a written test, students will be able to convert numbers from the decimal to binary system and from the binary to decimal system with 90% accuracy.

Entry Behaviors Defined

Entry behaviors are a key component in the design process (Dick & Carey, 1985). The entry behaviors of this project are the following:

1. A student who is accepted by the admission office to enroll in school.
2. Type of audience. NYIT graduate foreign student.
3. Pre-requisite skill. Basic knowledge in arithmetic (addition, subtraction, multiplication, and division). Student's age is at least 20.

Group and Sequence Objectives

In order to acheive the TPO, student must do the following:

1. State the digits 0 and 1 are the only ones used in the binary system.
2. Identify the set of binary values.
3. Write numbers in the binary system.
   - 3.1 Write the set of binary values.
   - 3.2 Select the set of binary values that its total is equal to the required decimal number.
   - 3.3 Write one (1) under the selected binary values, and else write zero (0).
4. State the difference between the decimal and binary system.

4.1 Write a small two (2) below the rightmost digit of binary number.

5. Use the rule to convert numbers from the decimal to binary system.

5.1 Use division rule.

5.2 Repeat dividing the decimal number by two (2) until the zero (0) quotient is obtained.

5.3 Write the remainders from each successive division.

5.4 State the remainders from the division process are recorded from the last to the first.

6. Use the rule to convert numbers from the binary to decimal system.

6.1 Use the expanded form.

6.2 Write the binary value to each digit of the binary number by starting from the rightmost digit with one (1).

6.3 Multiply each digit by its own value.

6.4 Total the sum of each multiplication.

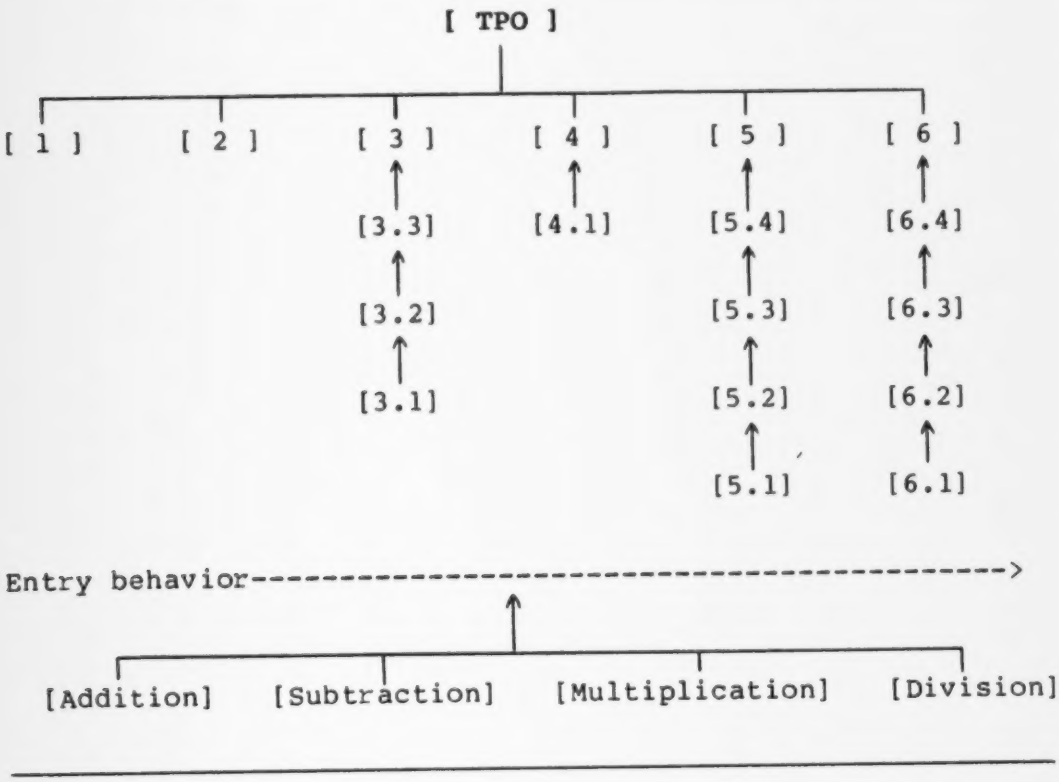
These are represented in a behavioral hierarchy in Table 1.

Learning Activities Specification

Learning types and conditions. These were specified according to the group and sequence objectives.

Table 1

Group and Sequence Objectives in a Behavioral Hierarchy



1. Given the rule and example, write a set of binary values.
2. Given a question asking students to recognize that only 0 and 1 are used in the binary system.
3. Given several examples, recognize the rule of representing numbers in the binary system.

   3.1 - 3.3

   Given examples, write the binary equivalents of decimal numbers and check the answer.

4. Given instruction and examples, state the rule to indicate the binary number system.

5. Given a written test, solve the problems.

   5.1 - 5.4

      Given the rule and several examples, practice converting numbers from decimal to binary.

      Given a self-test, practice solving problems.

6. Given a written test, solve the problems.

   6.1 - 6.4

      Given the rule and several examples, practice converting numbers from binary to decimal.

      Given a self-test, practice solving problems.

System Approach. The method of instruction used was programmed instruction as described by Garner (1966), Brethower (1976), and Wexley (1981).

Wexley (1981) divided programmed instruction into the following features:

1. **Objectives** - The designer defines behavioral objectives and the level of acceptable performance that students will be able to do after the training is completed.

2. **Own-pace** - Students are allowed to proceed at their own pace.

3. **Logical Sequence** - The materials are broken down into small steps or frames. Each step/frame consists of information followed by a question. The content is structured in a step-by-step sequence.

4. **Active Responding** - At the end of each frame, students are asked to make some response that measures comprehension of the material in that frame and to solve a problem.

5. **Knowledge of Results** - Students receive information immediately whether their response is correct or not. If it is, they are allowed to proceed to the next step. If it is not, their progress through the program is delayed.

Media Selection. The designer selected printed materials because it is easy to produce and less expensive than other media. Printed materials are available to everyone. The controlable variables and uncontrolable variables of printed materials are the following:

Controlable Variables

1. To provide directions and information
2. Students can stop at any point in the material to refer to other sources and can continue on anytime.
3. Students can proceed at their own pace.
4. Students can learn materials anywhere and anytime that is convenient to them.
5. Easy to review by both instructors and students.
6. Easy to produce.
7. Less cost.

Uncontrolable Variables

1. Printing time may take several days.
2. Students get bored.
3. Colored artwork is expensive to use in printed materials.

Level of Language. The self-instructional booklet described in this thesis/project was designed specifically for non-computer background students who may have related work with computers. The designer planned not to use technical terms or words in the materials, but to use simple terms that are easy to understand.

Assessment System Specification

The test system that the designer used was pretest, progress checks, and post test. Assignment of grades is based on a "pass" or "fail" strategy.

Pretest

A pretest was used to measure skills that are going to be taught in the program. It contains the "fill in the blank" question asking students to convert the number from decimal to binary system. The pretest helps to determine how much prior knowledge students have of what is going to be taught. If they can not pass the pretest, they must enroll in the binary number system training program. The pretest is included in Appendix 3.

Progress Checks

This is a practice item that used to measure students' knowledge after instruction. It was used prior to the post test. This step provides valuable data for the formative evaluation and revision of the instruction. It can be used for checking the progress of students. This item was included as a part of instructional strategy. The progress checks are included in the instructional materials in Appendix 5.

Post test

The post test was focused on the terminal performance objectives. It measures all skills that are taught in class. The post test is included in Appendix 4.

Evaluation System Specification

The evaluation systems used in this thesis/project are formative evaluation and summative evaluation.

Formative Evaluation

The designer conducted the formative evaluation during the development of instruction. It is used to improve the quality and effectiveness of instruction. The formative evaluation is divided into three steps: one-on-one trials, small group trials, and pilot testing (Dick & Carey, 1985).

I. One-on-One Trials

1. The designer will pick one student at a time from the target population and work individually with each

student. The number of students selected for one-on-one trials will be three to four students. The designer will take notes of any changes during the evaluation process.

2. Types of information that the designer will seek during the one-on-one trials are the following:

a. Can students perform all the skills identified in the group and sequence objectives?

b. What instruction is necessary to be added in the materials?

c. Do the instructional materials provide adequacy of vocabulary; clarity of description, examples, and feedback information; and adequacy of sequence of content and activities?

d. The time required to complete the materials.

e. Are the test instruction, vocabulary and test questions clear to students?

f. Are the objectives clear to the students?

These questions are adapted from types of questions that suggested by Dick & Carey (1985, p. 215).

3. The designer will present all the materials used in one-on-one trials to the subject matter specialist (SME). The SME will be asked to go through the materials. The designer will take notes of the changes and suggestions made by the SME.

II. **Small Group Trials**

The designer will select at least three to four students from the target population. The same materials as used in one-on-one trials will be presented. The designer will look for the same types of information as described in one-on-one trials. The advantage of using small group trials is to provide the designer an opportunity to observe and compare the reaction of students to the materials at the same time. This also helps to avoid the error of assuming that all students will respond in the same manner.

III. **Pilot Testing**

The ideal number of students to participate in the pilot testing of materials such as this self-instructional booklet is about thirty. This step helps to determine whether the materials are actually ready for use. The designer plans to collect the same types of information that will be obtained in one-on-one and small group trials.

Data Analysis Requirements. Types of data the designer plans to collect are the following:

1. Test data collected on pretest, progress checks, and post test.

2. Comments made by students about difficulties of the materials at a particular point.

3. Data collected on attitude questionnaires.

4. The time required for students to complete the materials.

5. Reactions of a SME.

Summative Evaluation

The purpose of summative evaluation is to describe the absolute effectiveness and feasibility of instruction (Dick & Carey, 1985). The summative evaluation as described by Kirkpatrick (1975, 1987) consists of four levels: reaction, learning, behavior, and results/impact.

Level 1 Reaction. The most commonly used approach to evaluating a training program is to assess students' reaction to the program (Friedman & Yarbrough, 1985). The designer will use pre-learning and post learning questionnaires to determine students' opinion toward the self-instructional program before and after the training session.

Level 2 Learning. The designer will use the test systems (pretest, progress checks, and post test) to measure students' achievement of program objectives.

Level 3 Behavior. This level will be used for measuring students' actual performance after the training program. This step would be conducted within sixty days after the training program is completed.

Level 4 Results/Impact. This level will be used for measuring the bottom line results of training. It can be used to determine the return on investment of training effort.

Data Analysis Requirement. Types of data that will be collected during the summative evaluation include the following:

1. Pretest scores.

2. Progress checks result.

3. Post test scores.

4. Time required to complete instruction.

5. Student's attitudes about the instruction and procedures. Data collected on attitude questionnaires.

Review of Existing Materials

None of the existing materials reviewed in Chapter 2 are closely related to the desired content and sequence of instruction. The designer did not select any existing materials to be included in the instructional materials.

Summary

The designer conducted an instructional task analysis to determine the major skills and subordinate skills students need to perform the tasks. The designer identified the instructional objectives, entry behaviors and sequenced objectives; specified learning activities; and planned test system as well as evaluation system. The program was designed as a self-instructional program using the programmed instruction for the teaching method.

Printed materials were selected for representing instructions. The designer also reviewed the existing materials in order to include them in the instructional materials, but none of them were selected.

CHAPTER 4

DEVELOPMENT

Introduction

In the development process, instructor and student activities were defined based on the task performance, objectives, entry behaviors, learning activity, and test systems produced in the Design phase. Instructional materials were developed, and the result was reviewed for its accuracy and effectiveness.

Learning Activity Design Produced

The designer used the method of lean programming described by Rummler (1973) to develop instructional materials. Lean programming is involved with

- task analysis
- criterion frame outline
- teaching frames which were developed with the idea in mind that the "small step" of programming should be the largest step a student can take without failure
- individual tryout to test the assumptions about a student's ability to take the step (Rummler, 1973, p. 211)

The designer first developed one lesson of the binary number system (binary number representation). The materials were presented with the smallest amount of instruction.

These instructional materials were then tested in a one-on-one trial setting. The designer also prepared supplementary instruction more detailed than the previous one. This additional instruction was used only if the designer found that a student did not understand the instruction first presented. By using the lean programming method, the instructional materials were presented with the optimum amount of instruction.

All of the remaining elements were developed based on the experience of developing the first lesson of binary number representation.

Learning Activity Development

The project described in this thesis/project is a self-instructional program. Therefore, the events of instruction were planned with different characteristics from the events that include instructors.

The instructional events were based on the nine events of instruction described by Gagne (1985). (See table 2)

1. **Gaining attention**
   - The designer developed a pre-learning questionnaire to used as an introduction to the program.
2. **Informing learners of the objective; activating motivation**

- State in writing that students will learn how to write the number in binary system, and learn how to convert numbers from decimal to binary and from binary to decimal.
- Provide concept of conversion techniques. Students can apply the concept to use in other number systems (such as octal or hexadecimal).

3. **Stimulating recall of prior learning**
   - Recall the previous learning by starting with the decimal number. It is the base system of other number systems. It will direct students to a new learning situation.
4. **Presenting the stimulus**
   - Students will be able to proceed at their own pace. If they can answer the questions, they will continue to the next step. If they can't, they must go back to the previous step and review the materials.
5. **Providing learning guidance**
   - Examples of the binary number and the decimal-binary conversion techniques.
   - Provide answers and explanation for each question.

6. **Eliciting performance**
   - Students are able to solve the problems and apply the basic understanding to use in the advanced step.
7. **Providing feedback**
   - The result from solving problem will give the direct feedback to students. They will see their progress and weakness.
8. **Assessing performance**
   - Given the problem-solving and self-test.
   - Given the pretest and post test, students will be able to see the result of their performance before and after a learning situation is entered.
9. **Enhancing retention and transfer**
   - Provide some examples and exercises to practice.
   - Apply the rule to solve the problems.

Development Process

Pre-learning Questionnaire and Post Learning Questionnaire. The designer designed and developed pre- and post learning questionnaires. The pre- and post learning questionnaires were based on the Likert scale as described by Henerson, Morris & Fitz-Gibbon (1986) and Wimmer & Dominick (1987). The question format is a multiple choice providing four responses (strongly disagree, disagree, agree, and strongly agree).

Table 2

Events of Instruction
1. Gaining attention
2. Informing learners of the objective; activating motivation
3. Stimulating recall of prior learning
4. Presenting the stimulus
5. Providing learning guidance
6. Eliciting performance
7. Providing feedback
8. Assessing performance
9. Enhancing retention and transfer

The pre-learning questionnaire contains five questions. It was used as an introduction to the training program and used to find out students' attitude toward the self-instructional program before the learning situation was entered. The pre-learning questionnaire is divided into three parts: objectives, instruction for completing questionnaire, and question items. The pre-learning questionnaire is shown in Appendix 6.

The post learning questionnaire contains sixteen questions. Ten out of sixteen are positive question items. The other five questions are negative items which were written in the opposite meaning from the positive items in order to double check students' responses. The last question (question item no. 16) is the demographic question. The post learning questionnaire was used to gather data about the effectiveness of the lesson on the binary number system and to find out students' attitude toward the self-instructional program after the training session. The post learning questionnaire is divided into three parts: objectives, instruction, and question items. The post learning questionnaire is shown in Appendix 7.

Pretest and Post Test. The pretest and post test were developed for measuring students' achievment of the learning objectives. The questions are based on a "fill in the blank" format.

The pretest contains one question asking students to convert the given decimal number to binary number system. (See Appendix 3)

The post test contains two questions. The first question item is the same question as presented in the pretest. The second question asks students to convert the given binary number to decimal number system. (See Appendix 4)

Self-instructional Booklet. The designer started developing the self-instructional booklet at the end of February, 1987. The instruction was developed on the basis of nine events of instruction. The instruction was presented piece by piece. Each piece of instruction was followed by a question. The feedback was provided immediately after the question on a separate page. The method of presenting instruction was based on programmed instruction. The contents of the self-instructional booklet are the following:

- Objectives
- About the self-instructional booklet
- Why we need to learn the binary number system?
- Review the decimal number system
- Binary number system (This section is divided into three parts: binary values, representing the binary number, and conversion technique.)
- Practice

The development process was completed as time planned. All the materials were then printed. Fifteen sets of self-instructional booklets were produced. The first version of the self-instructional booklet is shown in Appendix 5.

Training Plan

The steps of conducting the training program are the following:

1. Pre-learning questionnaire
2. Pretest
3. The self-paced instruction booklet
4. Post test
5. Post learning questionnaire

Learning Activity Review

After the development of instructional materials was completed, the materials were reviewed by the SME involved in the instructional development. The designer gathered information and took note of recommendations for future improvement.

The designer also performed an editing type review to ensure that all parts of the instruction were presented and formed a complete product responsive to the designed plan. The designer corrected mis-spellings as well as checked grammar, style, and punctuation of the instructional materials to confirm its accuracy.

Materials for Evaluation Produced

Fifteen sets of materials were produced for the summative evaluation process during the first two weeks of

March, 1987. The materials for evaluation are pretest, post test, pre-learning questionnaire, and post learning questionnaire.

Summary

The instructional materials were developed based on the method of Lean programming. The optimum amount of instruction was presented. The nine events of instruction were used for developing the instructional events. The materials were reviewed to confirm their effectiveness after the instructional development process was completed. The designer also produced the sets of evaluation materials (pretest, post test, pre- and post learning questionnaire). These items were developed during the first two weeks of March.

CHAPTER 5

IMPLEMENTATION

Introduction

The implementation process began after the development of the self-instructional booklet and materials for evaluation were completed. All the materials produced in the Development phase were evaluated in order to verify that students have achieved the learning objectives and to detect any problems that may occur. The designer was able to get feedback from the target population. The designer then used the result of trials to improve the effectiveness of instruction.

Materials Reproduced

The self-instructional booklet was produced twice. Fifteen copies were produced for the first try-out. After the formative evaluation process, the designer used data collected from the formative evaluation to revise the self-instructional booklet. Five sets of self-instructional booklets were produced for the second try-out. The final version of the self-instructional booklet is shown in Appendix 8.

Instructional Delivery

After the development process of the self-instructional booklet and evaluation materials were completed, the designer started to contact the pilot group in order to arrange the time and place to try out the materials.

First Try-out. There were six participants. The designer conducted one-on-one and small group trials. Each participant completed the pre-learning questionnaire and then took the pretest. One student passed the pretest; therefore, that student did not enroll in the training program. The actual number of students after the pretest was five. Those five students went through the instruction without any interruption from the designer. They were encouraged to write their answer, underline or circle the unclear words on the self-instructional booklet. They were allowed to proceed at their own pace through the instruction.

The designer found that students had problems in two areas. The unclear instruction and the format of instruction presented in the materials. The designer took notes of changes needed. After students completed all the materials presented in the self-instructional booklet, they took the post test. All of the students passed the post test. Students then completed the post learning questionnaire. The designer collected all the materials from students. Before the training session was completed,

the designer discussed the program, self-instructional booklet, questionnaires, and test systems with students. The designer took note of any suggestions made by students.

Second Try-out. The designer revised the materials on the basis of data collected from the first try-out. The designer selected the participants from the target population. There were three participants. The procedure used in the second try-out was similar to the first try-out. However, this time participants did not have any problems with the instruction presented in the self-instructional booklet. They also passed the post test.

Data Collection

1. Time required to complete the program is approximately 30 - 45 minutes.

2. Problems that encountered during the first try-out are the following: (See also Appendix 5 - The first version of self-instructional booklet)

Page 2 - did not know where to answer the first question.

Page 4 - one of participants could not answer the question; therefore, that participant could not answer questions on page 6 either because questions on page 4 and page 6 are

related to each other. That participant had to read the explanation on page 8, then was able to answer the questions on page 4 and page 6. Therefore, the designer switched the explanation on page 8 to be on page 6. If participants could not answer the question on page 4, they would read the explanation on page 6 and be able to answer the next questions on the following page.

Page 12 - 3 out of 5 participants did not know where to answer the questions because the instruction was not clear.

Page 15 - 3 out of 5 participants used the division rule to solve a problem on question #2 instead of using the binary value. The designer solved this problem by providing the set of binary values.

The designer found that participants like to use the division rule to convert the number from decimal to binary rather than to use the set of binary values because the division rule is easier.

3. The data collected from pre- and post learning questionnaire is shown here (See table 3, 4, 5, and 6).

Table 3

First Try-out: Pre-learning Questionnaire

Question No.	Number of Responses			
	SD	D	A	SA
1		1	3	1
2	2	1	1	1
3			3	2
4		1	2	2
5			3	2

Table 4

Second Try-out: Pre-learning questionnaire

Question No.	Number of Responses			
	SD	D	A	SA
1			3	
2		2		1
3		1	1	1
4			2	1
5			3	

SD - Strongly disagree

D - Disagree

A - Agree

SA - Strongly agree

Table 5

First Try-out: Post Learning Questionnaire

Question No.	Number of Responses			
	SD	D	A	SA
1			4	1
2			2	3
3		2	2	1
4		2	2	1
5		1	1	3
6	1	2	2	
7	1	2	2	
8			4	1
9		1	3	1
10	1	4		
11		1	3	1
12		1	2	2
13	1	3	1	
14	1	2	2	
15		5		

SD - Strongly disagree

D - Disagree

A - Agree

SA - Strongly agree

Table 6

Second Try-out: Post Learning Questionnaire

Question No.	Number of Responses			
	SD	D	A	SA
1				3
2			1	2
3			2	1
4		2	1	
5			3	
6		3		
7		1	1	1
8		1	2	
9			1	2
10	2	1		
11			1	2
12			3	
13		3		
14			3	
15	2	1		

SD - Strongly disagree

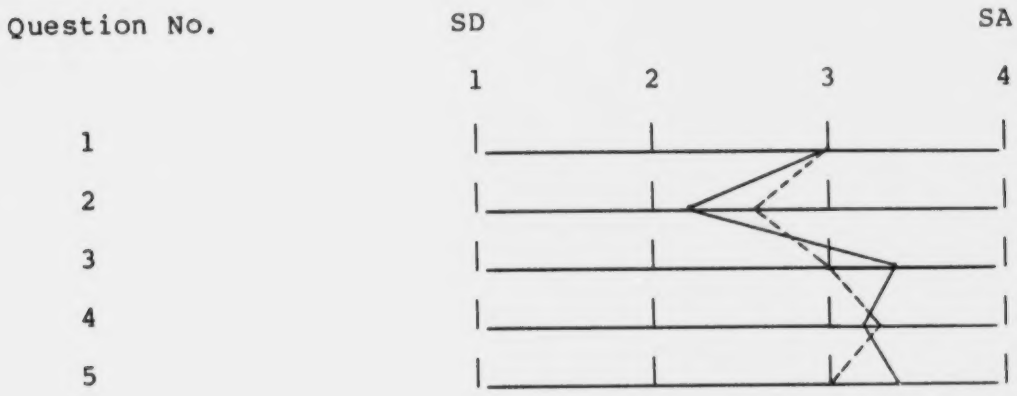
D - Disagree

A - Agree

SA - Strongly agree

Figure 1

The average score of the pre-learning questionnaire



SD - Strongly disagree

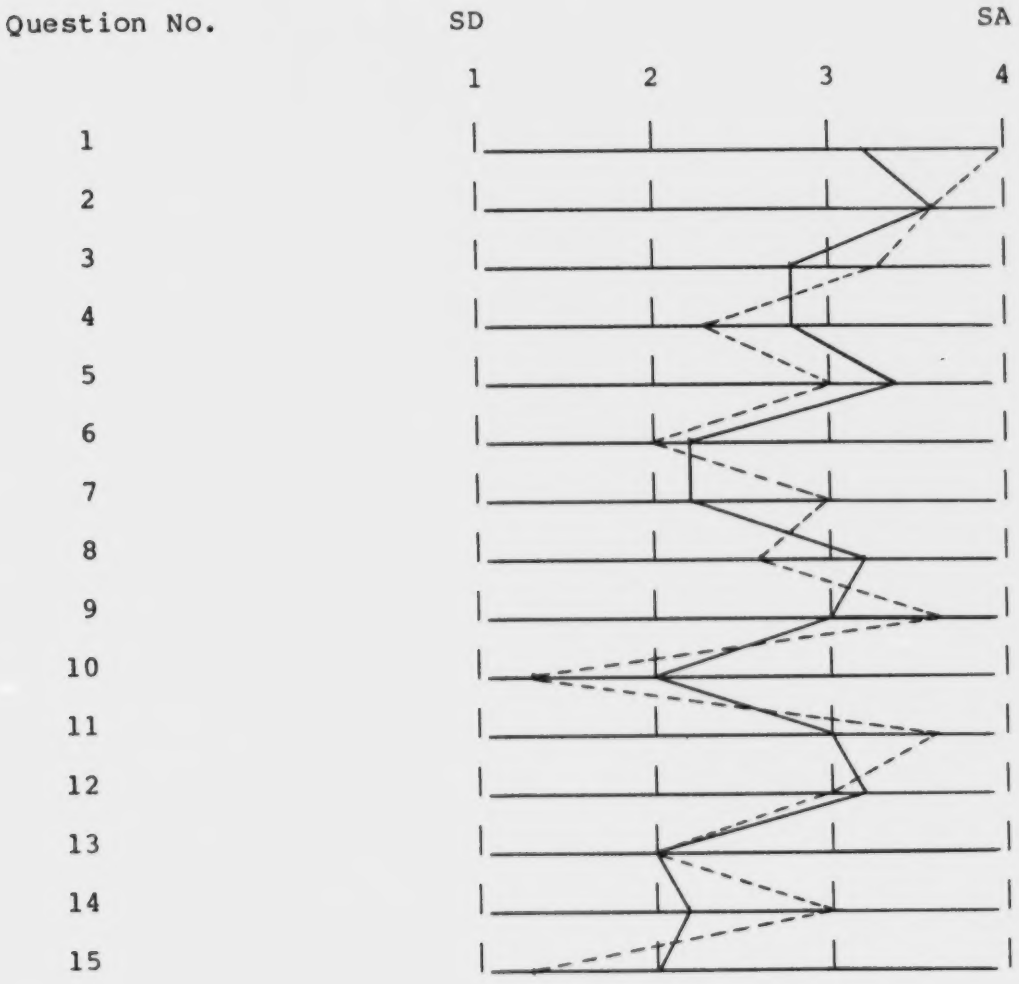
SA - Strongly agree

First Try-out Group ———

Second Try-out Group - - - - - - -

Figure 2

The average score of the post learning questionnaire



SD - Strongly disagree

SA - Strongly agree

First Try-out Group ————

Second Try-out Group - - - - - - -

4. The age of participants is in the range of 25-30. Seven out of eight participants are female. They have been in the U.S.A. for 1-2 years, and have been in their current fields for 6 months to 1 year. Two out of eight participants had an opportunity to use some self-instructional books before participating in the binary number system training program.

Summary

The designer delivered the training program as planned. Five students participated in the first try-out. The designer collected the data and took notes of any changes and suggestions. The first version of self-instructional booklet was revised based on the data collection and then reproduced for the second try-out. There were three students participating in the second try-out. All of the students from both try-outs passed the post test.

CHAPTER 6

EVALUATION

Introduction

Evaluation is a process of providing information to people involved in training regarding questions they want answered. It can be used as a mirror in which everyone that participated in the training process can see meaningful reflections of themselves (Friedman & Yarbrough, 1985). Margolis & Bell (1986) stated that "The last activity of most training programs is the learners' completion of some type of evaluation form. Such forms can provide you with valuable data on the learners' reactions to the program and their predictions regarding its usefulness on the job" (p. 115).

In the Evaluation phase, the designer conducted two types of evaluation. That is: formative evaluation and summative evaluation.

Formative Evaluation

Formative evaluation is defined as the determination of the effectiveness of instructional materials. The data and information collected from this step is used for improving the instruction. Dick & Carey (1985) described that "The emphasis in formative evaluation is on the collection of data in order to revise the instructional materials, to make the materials as effective as possible" (p. 198).

The designer conducted the formative evaluation during the development phase of instruction. There are three phases of a complete formative evaluation: one-on-one trials, small group trials, and pilot testing.

One-on-One Trials

The purpose of this phase is to identify and remove the most obvious errors in the instruction, and to obtain initial reactions to the content from students. There were five students participating in this phase. The designer worked individually with all five, one student at a time. The designer sat with a student while the student went through the materials. If a student failed to understand an example, the designer would carefully try another pre-planned verbal explanation or add a predetermined bit of information. The designer took note of changes and suggestions in writing during that period. The designer also prepared a table reflecting each page of the self-instructional booklet. When a student had a problem, for example on page 2, the designer wrote a checkmark on the table of page 2 and indicated the problems. This table helped to improve the instruction presented on each page of the self-instructional booklet.

After a student completed all the materials in the booklet; post test; and post learning questionnaire, the designer prepared oral questions to ask about the

instruction presented in the booklet. The questions are the following:

1. Was the instruction too difficult?
2. Was the program too long?
3. Did you have problems with any parts of the instruction?
4. How would you change the instruction if you could?
5. What did you like most?
6. What did you like least?
7. Would you prefer another instructional medium?

In summary, students responded that the instruction and the length of the program were appropriate. Students indicated that they have a problem with unclear instructions. They were not sure where to write the answer and they wanted this part to be improved. In most cases, they liked the instruction presented on page 4 of the self-instructional booklet. Students pointed out that some question items of the post learning questionnaire were unclear. Students prefered to learn about the binary number system from the self-instructional booklet.

The designer also presented all of the materials used in the one-on-one trials to the SME. The SME suggested a change to the format of the example on page 9. It was revised for the final version of the self-instructional booklet. (See Appendix 8 - page 9 of the final version booklet)

Small Group Trials

There were three students participating in this phase. The designer used the same materials as in one-on-one trials. The designer sat with students while they went through the materials. The designer asked the same type of questions as in one-on-one trials. The students' response was similar to that of the group of students in one-on-one trials.

Pilot Testing

The designer did not conduct the pilot testing phase of the formative evaluation primarily due to a lack of accessibility. Additionally, the materials have already been refined through two stages of careful evaluation during development.

Summative Evaluation

The summative evaluation was based on the four levels of evaluation as described by Kirkpatrick (1975, 1987). They are reaction, learning, behavior, and results/impact.

Level 1 Reaction

The first step in the summative evaluation process is to measure students' reaction to training program. It is important to determine how students feel about the program they attend. Any suggestions and comments obtained from students will be helpful in improving the future program. Kirkpatrick (1975) stated that "Reaction may best be defined

as how well the trainees like a particular training program" (p. 1). He emphasized that reaction is easy to measure and does not include a measurement of any learning that takes place (Kirkpatrick, 1975).

The designer used pre- and post learning questionnaires to measure students' reaction. The pre-learning questionnaire was used prior to the training session. The post learning questionnaire was used after the training session was over.

According to the data collected from the pre- and post learning questionnaires, the designer found that most students agreed that working individually allows them to do the best work and to proceed at their own pace through the materials. They have a positive attitude toward the self-instructional program (see also table 3, 4, 5, and 6 in chapter 5). However, they prefer to learn in a regular class rather than by themselves.

Level 2 Learning

Kirkpatrick (1975) stated that it is more difficult to evaluate learning where principles and facts are taught rather than techniques; therefore, the most common technique that designers can use is the paper-and-pencil test. The materials used to evaluate this level are pretest, progress checks, and post test.

One out of nine students passed the pretest. Therefore, that student did not participate in the training

session. All the rest failed the pretest. The progress checks results indicated that students were able to solve the problems and answer the questions in the self-instructional booklet. After the training session was over, students took the post test. All of the students passed the post test (see diagram 1).

Diagram 1

Pretest and Post Test Results

N = 9

	Pretest	Training (Time required 30-45 min.)	Post Test
Students	1 Pass	O	--
	8 Fail	X	8 Pass

Level 3 Behavior and Level 4 Results/Impact

The designer did not conduct the last two levels of summative evaluation during this project. They are discussed, in principle, in Chapter 3. However, if they were conducted, they would be the following:

Behavior. The designer will contact students sixty

days after the training program. Students will be invited to participate in the follow-up session. In this session, students will have an opportunity in analyzing their experience using the new skills/knowledge learned. Students will indicate how they are applying what they learned from the program. The designer plans to provide an article or news item that relates to the content of the program to each student. The designer will also send a report, which resulted from the follow-up session, to students who are unable to participate in the session in order to share information and keep them informed about what is happening.

Results/Impact. Students' improved knowledge will result in better understanding of how a computer operates, improve their ability, and complete the required core courses in computer science with a satisfactory grade. As a part of follow-up, the designer will encourage students to identify other learning needs. Learning can open many doors, and some of them may relate to the previous learning (such as an octal or hexadecimal number system). Nadler (1982) stated that "Learning is a continuous process. As a result of a good training experience, the learner may discover that there is much he does not know about other areas" (p. 243).

The designer will encourage students to apply their new skills/knowledge to use in learning other programs. Additionally, other factors such as attitudes, interest, and work involvement will also be measured.

Reliability and Validity

Reliability and validity refer to different aspects of training credibility. Reliability refers to the consistency of the criteria measures (Goldstein, 1974). Validity indicates to what degree materials are appropiate for what need to be measured or taught (Morris & Fitz-Gibbon, 1985).

The materials used in the project described in this thesis/project (self-instructional booklet, pretest, and post test) appear to be reliable and valid. The materials are valid, if they are used in the same way everytime. They will then produce the same result. However, there is a need to ensure that the use of materials is not rushed and enough time is allowed to respondents.

In this project, validity was addressed by using the opinions of judges to assess the materials' validity. The designer presented the materials to the SME. After a careful review, the SME approved that the materials taught what they purported to teach.

Reliability was addressed by using the results from the post test. After participating in the training program, all eight students, who failed the pretest, passed the post test. This means that whenever the materials are used, they consistently produce the same result.

The factors that affect the reliability of materials are the following:

1. The difference among students being measured.
2. The range of ability among students. The group may be composed of students with different levels of skills or knowledge.
3. Variation in conditions during measurement period.

Summary

The result of formative evaluation indicated that the self-instructional booklet about the binary number system was appropriate. It required only a minor change to improve the effectiveness of the instruction. After revision, the second group of students did not have any difficulty throughout the materials.

The results of summative evaluation provided the designer with evidence about the students' reaction to the program as well as their learning achievement. Students had a positive attitude toward the program. Besides, all of the students passed the post test. The materials used in this project appear to be reliable and valid.

CHAPTER 7

SUMMARY AND RECOMMENDATIONS

Introduction

In this phase, the contents of the project described in this thesis/project are summarized. It concludes with recommendations providing suggestions to anyone who may want to extend what the designer had done to another area or another group of population.

Methods and Procedures Used

The method used in developing the training program was based on the Instructional Systems Implementation (ISD) model. The ISD model was analyzed and divided into five phases: analysis, design, development, implementation, and evaluation.

Analysis

The designer analyzed the training needs, defined needs and analyzed the target population on the basis of knowledge gained from review of the professional literature, equipment, experience and observation, and survey of existing courses. The designer then defined and classified the instructional goal.

The training program was planned to be a self-instructional program which allows students to proceed at their own pace. The designer also used time lines and

PERT to plan the overall development of the self-instructional program. The development of the project started on February 9, 1987 and finished on May 11, 1987.

Design

The designer conducted an instructional task analysis, and identified the instructional objectives. The entry behaviors, group and sequence objectives, and learning activities were determined during this step.

The method of instruction used in this project is programmed instruction. Printed materials were selected. The self-instructional booklet was designed specifically for non-computer background students. The test system (pretest, progress checks, and post test) was used to measure students' achievement. The evaluation system used in this project is formative and summative evaluation.

Development

The designer used the method of lean programming to develop instructional materials. The instructional events were based on the nine events of instruction. In this phase, pre- and post learning questionnaires, pretest, post test, and self-instructional booklet were developed. After the development process was completed, all of the materials were reviewed by the SME. Fifteen sets of materials were produced.

Implementation

All the materials produced in the Development phase

were evaluated in order to verify the effectiveness and detect problems that may occur. The designer collected data and used it to revise the instructional materials. The final version of the self-instructional booklet was then produced and tested.

Evaluation

The designer conducted formative evaluation procedures during the development of the instructional materials. The designer conducted one-on-one and group trials. The last activity of this step was to conduct summative evaluation. The designer conducted only the first two levels of summative evaluation; reaction and learning.

Conclusions

The result of formative evaluation indicated that the self-instructional booklet needed a minor change. The contents and level of language used were appropriate for the graduate foreign students at NYIT.

The result of summative evaluation indicated that students had a positive attitude toward the self-instructional program. All participants from both try-outs passed the post test and achieved the TPO.

It appears that the binary number system training program is appropriate for the graduate foreign students. The results of the program are very satisfactory. They are certainly worth the effort to design and develop this project.

Recommendations

1. If the designer were able to conduct pilot testing, the designer could ensure that the materials are ready for the market. Besides, it will help to focus on important components in the materials better than one-on-one and group trials.

2. The contents of the program could be extended to addition, subtraction, multiplication, and division in the binary number system as well as other number systems (such as octal or hexadecimal).

3. Learning does not end when the session is over. A good program can encourage students to review and extend their learning to their performance. Students can apply the concept learned in this program to use in other programs. However, it is important to identify other programs that will supplement, reinforce, and continue the learning process that has been initiated. The designer can do several things to promote continuing learning:

    1. Send each student an article or news item related to the content of the program.
    2. Phone or write students sixty days after the program in order to ask how they are applying what they learned.
    3. Organize follow-up meetings, and let students analyze their experience using the new skills/ knowledge learned in the training session.

Concluding Statement

A great deal of time and effort was invested in designing and developing the training program described in this thesis/project. Hopefully, its result can be useful for anyone who has an interest. The knowlege gained from learning the binary number system should benefit students with little, or even without, experience in computer science. That is what this project attempts to provide.

This thesis/project should serve as the greatest possible source of encouragement and guidelines to those who may, in the future, be responsible for a training or development project.

APPENDIX 1

PROJECT PLANNING

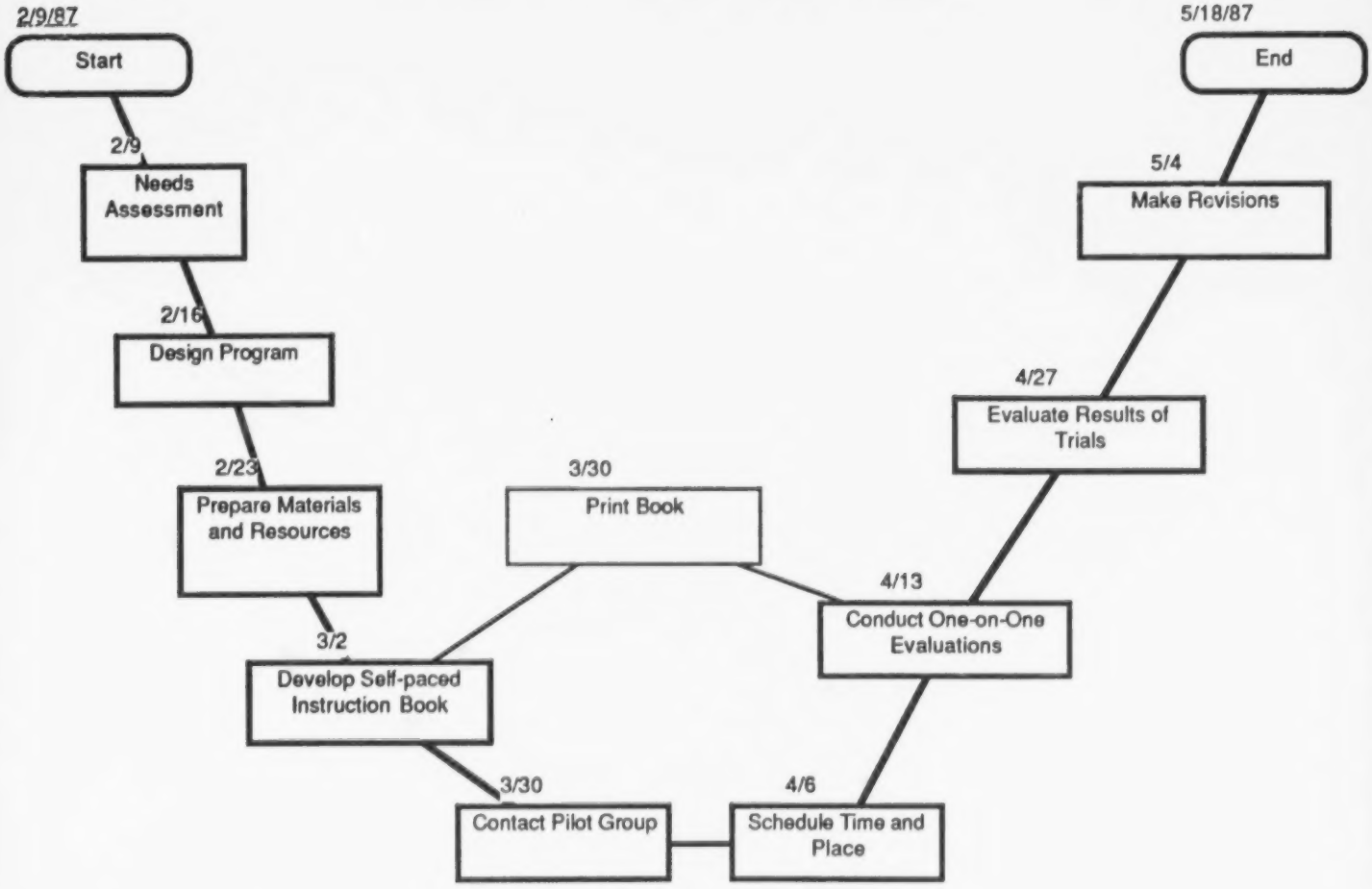
Time Lines

	Weeks	Start	Finish
1. Start	0	2/9/87	2/9/87
2. Needs assessment	1	2/9/87	2/15/87
3. Design program	1	2/15/87	2/21/87
4. Prepare materials and resources	1	2/21/87	2/27/87
5. Develop self-paced instruction book	4	2/27/87	3/26/87
6. Contact pilot group	1	3/26/87	4/1/87
7. Print book	1	3/26/87	4/1/87
8. Schedule time and place	1	4/1/87	4/7/87
9. Conduct one-on-one and small group evaluation	2	4/7/87	4/21/87
10. Evaluate results of trials	1	4/21/87	4/28/87
11. Make revision	2	4/28/87	5/11/87
12. End	0	5/11/87	5/11/87

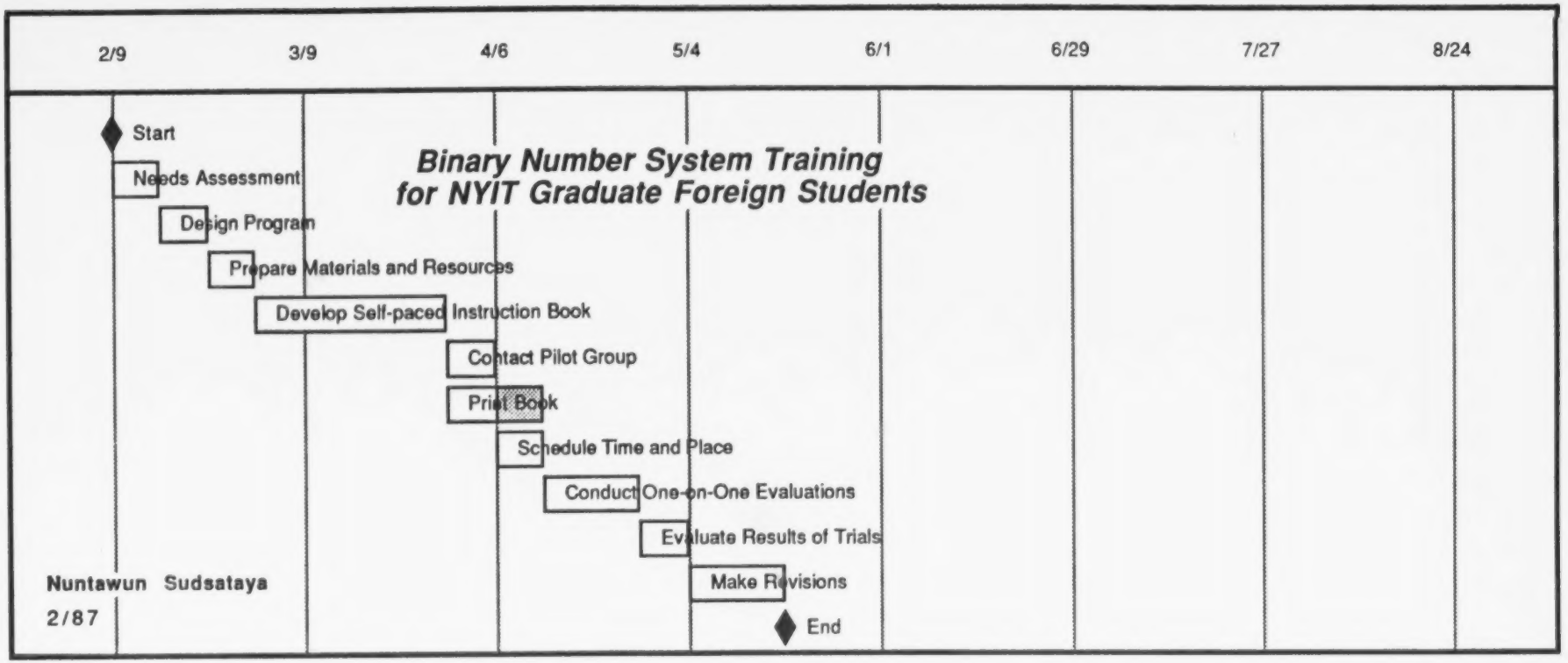
Binary Number System Training for NYIT Graduate Foreign Students

	Task Name	Weeks	Earliest Start	Earliest Finish	Latest Start	Latest Finish	Fixed Cost	Resource Cost
1	Start	0	2/9/87	2/9/87	2/9/87	2/9/87	0	0
2	Needs Assessment	1	2/9/87	2/16/87	2/9/87	2/16/87	0	0
3	Design Program	1	2/16/87	2/23/87	2/16/87	2/23/87	0	1800
4	Prepare Materials and	1	2/23/87	3/2/87	2/23/87	3/2/87	0	1800
5	Develop Self-paced	4	3/2/87	3/30/87	3/2/87	3/30/87	0	7200
6	Contact Pilot Group	1	3/30/87	4/6/87	3/30/87	4/6/87	0	0
7	Print Book	1	3/30/87	4/6/87	4/6/87	4/13/87	100	1800
8	Schedule Time and Place	1	4/6/87	4/13/87	4/6/87	4/13/87	0	1800
9	Conduct One-on-One	2	4/13/87	4/27/87	4/13/87	4/27/87	0	3600
10	Evaluate Results of Trials	1	4/27/87	5/4/87	4/27/87	5/4/87	0	1800
11	Make Revisions	2	5/4/87	5/18/87	5/4/87	5/18/87	0	3600
12	End	0	5/18/87	5/18/87	5/18/87	5/18/87	0	0

Binary Number System Training for NYIT Graduate Foreign Students



Nuntawun Sudsataya
2/87


2/9
3/9
4/6
5/4
6/1
6/29
7/27
8/24
Start
Needs Assessment
Design Program
Prepare Materials and Resources
Develop Self-paced Instruction Book
Contact Pilot Group
Print Book
Schedule Time and Place
Conduct One-on-One Evaluations
Evaluate Results of Trials
Make Revisions
End
Binary Number System Training
for NYIT Graduate Foreign Students
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APPENDIX 2

TASK ANALYSIS

Task Analysis

- The digits that are used in the binary number system.

- The set of values in the binary number system.

- The method of representing the binary number system.
  1. Use the binary values.
  2. Select the set of binary values that its total is equal to the required number in decimal.
  3. Write one to the selected values, or else write zero.

- The difference between the decimal and binary number system.
  1. Write a small two below the rightmost digit of binary number to indicate it is binary.

- The decimal conversion technique.
  1. Apply division rule.
  2. Repeat dividing the decimal number by two until the zero quotient is obtained.
  3. Record the remainder from each division.
  4. Write the remainders from the division process from the last to the first.

- The binary conversion technique.
  1. Apply the expanded form.
  2. Assign the binary values to each digit of the binary number starting from the rightmost digit with the smallest binary value, one.
  3. Multiply each digit by its assigned value.
  4. Total the sum of each multiplication.

Entry Behavior Line

Addition Subtraction Multiplication Division

APPENDIX 3

PRETEST

PRETEST

Write the number 17 in the binary number system.

Answer: _____

APPENDIX 4

POST TEST

POST TEST

1. Write the number 17 in the binary number system.

Answer: _____

2. Convert the binary number 10100_2 to decimal.

Answer: _____

APPENDIX 5

INSTRUCTIONAL MATERIALS

(FIRST VERSION)

INTRODUCTION TO THE BINARY NUMBER SYSTEM

Nuntawun Sudsatava

April 1987

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Division rule	9
Binary conversion	12
Practice	15

Welcome to the introduction to the Binary Number System Training course. Upon completion of this course, you will be able to

- Write numbers in the binary number system and its equivalence of decimal numbers.
- Convert numbers from the decimal to binary, and from the binary to decimal number system with 90% accuracy.

ABOUT THIS BOOKLET

This is a self-instructional booklet. You will be able to learn without any required explanation from an instructor. You are allowed to proceed at your own pace through the booklet.

This booklet provides you some examples and questions. You need to consider each example carefully. The questions will help you understand the materials. You will be able to check your answers after that; however, please try not to look at the answers before completing the questions.

GOOD LUCK

(iii)

WHY WE NEED TO LEARN THE BINARY NUMBER SYSTEM

We are very familiar with the decimal number system because we use it for counting everything. However, computers can't understand our language or the decimal number system. They can understand only the binary number system. A computer will translate all commands and data into the binary number system.

Even though you are not a programmer, I believe that at least once you have used a computer. Therefore, you should know how a computer operates. This means you need to understand the binary number system and the uses of it.

DECIMAL NUMBER SYSTEM

As I stated early in this book, we are very familiar with this system because we use it everyday.

Decimal means **ten**. If you remember when you were a child, you used your ten fingers to count any numbers such as 1,5,9,14,20,26 and so forth.

Since you have already learned the decimal number system, why don't we start learning **the binary number system.**

Please turn to **page 2**

BINARY NUMBER SYSTEM

First of all, we need to know the binary value.

The binary value is the following:

1

2

4

8

16

_____ <---- What would this value be?

64

128

Please answer the following questions.

1. According to the list of binary value above, the smallest value is _____.

2. Do you think 256 is one of the binary values?

Answer _____

Answer:

This value would be 32.

1. the smallest value is 1.

2. Yes, because the binary value is derived from 2 times the previous value (or the power of 2).

Therefore 128 x 2 = 256

Representing the binary number system

You need to use the binary value that you have just learned to represent numbers in the binary system.

Please consider the following examples.

Binary value					
16	8	4	2	1	Decimal number
N	N	N	N	N	0
N	N	N	N	Y	1
N	N	N	Y	N	2
N	N	N	Y	Y	3
N	N	Y	N	N	4

Assign: N (No) = 0

Y (Yes) = 1

Please fill in the blanks

Binary value							
16	8	4	2	1	Binary number		Decimal number
0	0	0	0	0	0	=	0
0	0	0	0	1	1	=	1
0	0	0	1	0	1 0	=	2
0	0	0	1	1	1 1	=	3
0	0	1	0	0	1 0 0	=	4
0	0	1	0	1	____	=	5
0	0				____	=	6
0	0				____	=	7

(5)

Answer:

		Binary number		Decimal Number
		101	=	5
00110	or	110	=	6
00111	or	111	=	7

Please fill in the blanks.

Write the numbers 9 to 15 in the binary number system. using the binary value.

Hint. Use the same method as shown on page 4.

Binary value							
16	8	4	7	1	Binary number		Decimal number
0	1	0	0	0	---> 1000	=	8
0	1		0		_____	=	9
0		0	1		_____	=	10
0	1			1	_____	=	11
0			0		_____	=	12
0				1	_____	=	13
0				0	_____	=	14
0	1				_____	=	15

Answer:

Binary Number				Decimal Number
01001	or	1001	=	9
01010	or	1010	=	10
01011	or	1011	=	11
01100	or	1100	=	12
01101	or	1101	=	13
01110	or	1110	=	14
01111	or	1111	=	15

Remark: You should read, for example, binary number 1001 (one zero zero one); binary number 1111 (one one one one).

If your answers are correct, please turn to **page 9.**

If your answer are different, please turn to **page 8.**

You know that the binary value is **16 8 4 2 1.**

In order to write the number 8 in the binary number system, you must select the binary value that is equal to 8. Then you assign 1 to the value 8, or else assign 0.

How about the number 9? There is no value 9 in the binary value; therefore, you must select the binary value 8 and 1 instead because 8+1 = 9. Then assign 1 to the selected value, in this case 8 and 1, or else assign 0.

To make it clear, please consider the examples below.

Decimal 8

↓

Binary value

16	8	4	2	1	Binary number		Decimal number
0	1	0	0	0	1000	=	8

Decimal 9

↓

Binary value

16	8	4	2	1	Binary number		Decimal number
0	1	0	0	1	1001	=	9

If the number is large such as 200, it takes time to use the previous method (binary value) to write the number in binary. Therefore, we will apply the division rule to convert the numbers in decimal to binary.

Please consider the following example

Decimal 200

```
2)200
  100          remainder 0
   ↓
2)100
   50          remainder 0
   ↓
2) 50
   25          remainder 0
   ↓
2) 25
   12          remainder 1
   ↓
2) 12
    6          remainder 0
    ↓
2)  6
    3          remainder 0
    ↓
2)  3
    1          remainder 1
    ↓
2)  1
    0          remainder 1 <---
```

Decimal 200 = $1\ 1\ 0\ 0\ 1\ 0\ 0\ 0_2$

Fill in the blanks.

Convert decimal 125 to binary

2)125

62 remainder 1

2) 62

31 remainder 0

2) 31

15 remainder ____

2) 15

__ remainder ____

2)___

__ remainder _____

2)___

__ remainder _____

2)____

== remainder _____ <--

125 = _ _ _ _ _ 0 1_2

↑

Answer:

2) 125		
62	remainder	1
2) 62		
31	remainder	0
2) 31		
15	remainder	1
2) 15		
7	remainder	1
2) 7		
3	remainder	1
2) 3		
1	remainder	1
2) 1		
0	remainder	1 <—

$125 = 1\,1\,1\,1\,1\,0\,1_2$

NOTE: To eliminate confusion, you must write a small two ($_2$) below the rightmost digit to indicate it is a binary number.

Binary conversion

Since you know how to convert the numbers from decimal to binary by using the binary value and the division rule, now you will learn how to convert the binary numbers back to the decimal.

Recall

The binary value is .. 16 8 4 2 1

Please consider the following examples.

The binary number 111 is equal to __??__ in decimal.

Binary value

16	8	4	2	1	
		1	1	1	= 7

Convert 1010_2 to decimal

Binary value

16	8	4	2	1	
	1	0	1	0	= 10

Convert 1101_2 to decimal

Binary value

16	8	4	2	1	
	1	1	0	1	= Answer _____

Convert 11011_2 to decimal

Binary value

16	8	4	2	1	
					= Answer _____

Answer:

1101 = 13

11011 = 27

If your answers are correct, please turn to **page 14.**

If your answers are incorrect, please read the explanation below and try again.

We use the same method as representing the binary number system. For example:

Convert 1101_2 to decimal.

Binary value

16	8	4	2	1
	1	1	0	1

$= (8\times1)+(4\times1)+(2\times0)+(1\times1)$

$= 8 + 4 + 0 + 1$

$= 13$

Convert 1111_2 to decimal.

Binary value

16	8	4	2	1
	1	1	1	1

= Answer _____

Answer

$1111_2 = 15$

GREAT! You are ready to practice your skill.

Turn to **page 15** and **answer all the questions.**

Then check your responses on pages 16 and 17.

PRACTICE

1. The binary number system requires only two digits; what would those two digits be?

Answer: _____ and ____

2. Convert the decimal 19 to binary, using the binary value.

3. Convert the decimal 203 to binary, using the division rule.

4. Convert 11000_2 to decimal.

Answer:

1. The binary number system requires only the digits **0 and 1**.

2.

Binary value					Decimal number		Binary number
16	8	4	2	1			
1	0	0	0	0	16	=	10000_2

3.

```
2 )203
   101        remainder 1
2 )101
    50        remainder 1
2 ) 50
    25        remainder 0
2 ) 25
    12        remainder 1
2 ) 12
     6        remainder 0
2 )  6
     3        remainder 0
2 )  3
     1        remainder 1
2 )  1
     0        remainder 1 <--+
                             |
203 = 11001011₂              |
      ↑______________________|
```

4. 11000_2

Binary value

16	8	4	2	1	
1	1	0	0	0	= 24

Congratulations!

You have just completed the self-instructional course, and now you are ready to test your skill.

APPENDIX 6

PRE-LEARNING QUESTIONNAIRE

Pre-Learning Questionnaire

To guide us in planning future training programs, we need to know your overall opinion about learning from a book by yourself without an instructor and without attending a class. Your response will help us serve you better.

Instructions:

After reading each of statements listed below, please write an x in the box [ ] to indicate whether you strongly disagree (SD), disagree (D), agree (A), or strongly agree (SA). Using either a pen or a pencil.

1. Working individually allows me to do the best work.

   [ ] SD [ ] D [ ] A [ ] SA

2. I enjoy reading a book that uses only simple words.

   [ ] SD [ ] D [ ] A [ ] SA

3. I like to study whenever I want.

   [ ] SD [ ] D [ ] A [ ] SA

4. I feel responsible for my study.

   [ ] SD [ ] D [ ] A [ ] SA

5. I would like to read a book at my own speed.

   [ ] SD [ ] D [ ] A [ ] SA

APPENDIX 7

POST LEARNING QUESTIONNAIRE

POST LEARNING QUESTIONNAIRE

The purpose of this questionnaire is to find out how do you feel about the lesson of binary number system that you have just finished. Your opinion will help us make a better lesson for you. This will take only five minutes of your time to answer all the questions.

Instructions:

After reading each of statements listed below, please write an x in the box [ ] to indicate whether you strongly disagree (SD), disagree (D), agree (A), or strongly agree (SA). Using either a pen or a pencil.

1. The objectives of this course were stated clearly.

   [ ] SD [ ] D [ ] A [ ] SA

2. Taking the tests helps me know if I really understand the materials.

   [ ] SD [ ] D [ ] A [ ] SA

3. Working individually allows me to do the best work.

   [ ] SD [ ] D [ ] A [ ] SA

4. Working in a group helps me to do my best work.

   [ ] SD [ ] D [ ] A [ ] SA

5. I learned a lot from the book about the binary number system.

   [ ] SD [ ] D [ ] A [ ] SA

SD - Strongly Disagree

D - Disagree

A - Agree

SA - Strongly Agree

6. I tried to just finish the lesson rather than to learn the materials.

[ ] SD [ ] D [ ] A [ ] SA

7. I am much more interested in learning by myself than before.

[ ] SD [ ] D [ ] A [ ] SA

8. For me, learning in a regular class is more interesting than learning by myself.

[ ] SD [ ] D [ ] A [ ] SA

9. The instruction made it easy to understand the materials.

[ ] SD [ ] D [ ] A [ ] SA

10. It is hard for me to understand the materials in the book.

[ ] SD [ ] D [ ] A [ ] SA

11. The book allowed me to proceed at my own pace.

[ ] SD [ ] D [ ] A [ ] SA

12. I believe that one picture is worth more than a thousand words.

    [ ] SD [ ] D [ ] A [ ] SA

13. I wish I could study without taking a lecture.

    [ ] SD [ ] D [ ] A [ ] SA

14. I will take more lessons in this kind of program.

    [ ] SD [ ] D [ ] A [ ] SA

15. I will not recommend anybody take the lessons in this kind of program.

    [ ] SD [ ] D [ ] A [ ] SA

16. Could you tell us a little bit about yourself? Information we obtain from you will have no effect on your grade, and it will be kept in confidence. Please place an x in the box [ ] by the one best response.

    a. Sex

        [ ] Male

        [ ] Female

    b. Your age is in the range of

        [ ] Less than 20

        [ ] 20 to 24

        [ ] 25 to 30

        [ ] 31 to 34

        [ ] 35 or more

c. How long have you been in the U.S.A.?

[ ] Less than 1 year

[ ] 1 to 2 years

[ ] 3 to 4 years

[ ] 5 to 6 years

[ ] More than 6 years

d. How long have you been in your current field?

[ ] Less than 6 months

[ ] 6 months to 1 year

[ ] 2 to 3 years

[ ] 4 to 5 years

[ ] More than 5 years

e. Have you ever used a self-instructional book before?

[ ] Yes. If yes, how many times did you use it? ___

[ ] No.

APPENDIX 8

INSTRUCTIONAL MATERIALS

(FINAL VERSION)

INTRODUCTION TO THE BINARY NUMBER SYSTEM

Nuntawun Sudsatava

April 1987

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Practice	15

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GOOD LUCK

(iii)

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We are very familiar with the decimal number system because we use it for counting everything. However, computers can't understand our language or the decimal number system. They can understand only the binary number system. A computer will translate all commands and data into the binary number system.

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As I stated early in this book, we are very familiar with this system because we use it everyday.

Decimal means **ten.** If you remember when you were a child, you used your ten fingers to count any numbers such as 1,5,9,14,20,26 and so forth.

Since you have already learned the decimal number system, why don't we start learning **the binary number system.**

Please turn to **page 2**

BINARY NUMBER SYSTEM

First of all, we need to know the binary value.

The binary value is the following:

1
2
4
8
16
32
64
128

Please answer the following questions.

1. What would this value be?

   Answer _____

2. Do you think 256 is one of the binary values?

   Answer _____

Answer:

1. This value would be 32.
2. If your answer is Yes. you are right.

Please turn to page 4.

If your answer is No. please read the explanation below.

The number 256 is one of the binary value because the binary value is derived from 2 times the previous value (or the power of 2).

Therefore 128x2 = 256

Turn to page 4.

4. 11000_2

Binary value

16	8	4	2	1	
1	1	0	0	0	= 24

Congratulations!

You have just completed the self-instructional course, and now you are ready to test your skill.

Representing the binary number system

You need to use the **binary value** that you have just learned to represent numbers in the binary system.

Please consider the following examples.

Binary value

16	8	4	2	1	Decimal number
N	N	N	N	N	0
N	N	N	N	Y	1
N	N	N	Y	N	2
N	N	N	Y	Y	3
N	N	Y	N	N	4

Assign: **N** (No) = **0**

Y (Yes) = **1**

Please fill in the blanks

Binary value

16	8	4	2	1	Binary number		Decimal number
0	0	0	0	0	0	=	0
0	0	0	0	1	1	=	1
0	0	0	1	0	1 0	=	2
0	0	0	1	1	1 1	=	3
0	0	1	0	0	1 0 0	=	4
0	0	1	0	1	_____	=	5
0	0				_____	=	6
0	0				_____	=	7

(5)

Answer:

		Binary number		Decimal Number
		101	=	5
00110	or	110	=	6
00111	or	111	=	7

If your answers are correct, please turn to **page 7.**

If your answers are different, please turn to **page 6.**

(6)

You know that the binary value is **16 8 4 2 1.**

In order to write the number 4 in the binary number system, you must select the binary value that is equal to 4. Then you assign 1 to the value 4, or else assign 0.

How about the number 5? There is no value 5 in the binary value; therefore, you must select the binary value 4 and 1 instead because 4+1 = 5. Then assign 1 to the selected value, in this case 4 and 1, or else assign 0.

To make it clear, please consider the examples below.

Decimal 4

↓

Binary value

16	8	4	2	1
0	0	1	0	0

Binary number: 100 = Decimal number: 4

Decimal 5

↓

Binary value

16	8	4	2	1
0	0	1	0	1

Binary number: 101 = Decimal number: 5

Please fill in the blanks.

Write the numbers 9 to 15 in the binary number system, using the binary value.

Hint: Use the same method as shown on page 4.

Binary value							
16	8	4	2	1	Binary number		Decimal number
0	1	0	0	0	---> 1000	=	8
0	1		0		_____	=	9
0		0	1		_____	=	10
0	1			1	_____	=	11
0			0		_____	=	12
0				1	_____	=	13
0				0	_____	=	14
0	1				_____	=	15

(8)

Answer:

		Binary Number		Decimal Number
01001	or	1001	=	9
01010	or	1010	=	10
01011	or	1011	=	11
01100	or	1100	=	12
01101	or	1101	=	13
01110	or	1110	=	14
01111	or	1111	=	15

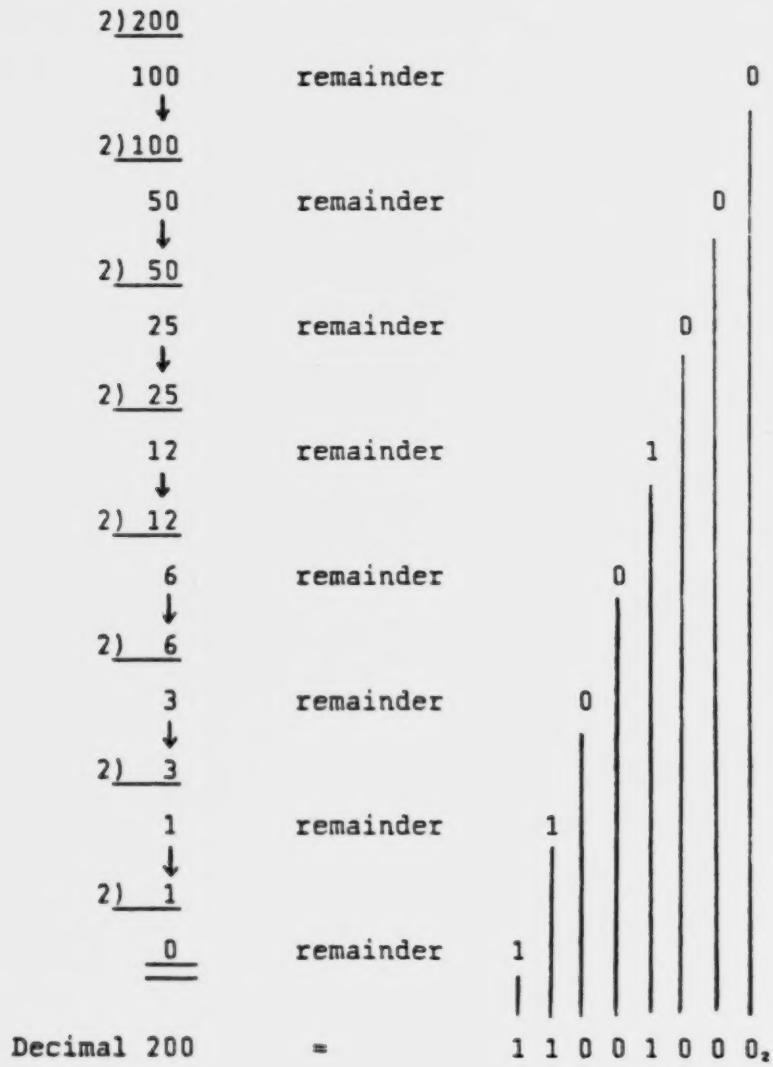
Remark: You should read, for example, binary number 1001 (one zero zero one); binary number 1111 (one one one one).

Division rule

If the number is large such as 200, it takes time to use the binary value to write the number in binary. Therefore, we will apply the division rule to convert the numbers from decimal to binary.

Please consider the following example.

Convert decimal 200 to binary.



Fill in the blanks.

Convert decimal 125 to binary.

2)125		
62	remainder	1
2) 62		
31	remainder	0
2) 31		
15	remainder	___
2) 15		
___	remainder	___
2)___		
___	remainder	___
2)___		
___	remainder	___
2)___		
___	remainder	___

$125 = _____0\ 1_2$

(11)

Answer:

2)125		
62	remainder	1
2) 62		
31	remainder	0
2) 31		
15	remainder	1
2) 15		
7	remainder	1
2) 7		
3	remainder	1
2) 3		
1	remainder	1
2) 1		
0	remainder	1

$125 = 1\,1\,1\,1\,1\,0\,1_2$

NOTE: To eliminate confusion, you must write a small two ($_2$) below the rightmost digit to indicate it is a binary number.

Binary conversion

Since you know how to convert the numbers from decimal to binary by using the binary value and the division rule, now you will learn how to convert the binary number back to the decimal number.

Recall

The binary value is . . 16 8 4 2 1

Please consider the following examples.

Convert 111_2 to decimal

Binary value

16	8	4	2	1
0	0	1	1	1

= 7

Convert 1010_2 to decimal

Binary value

16	8	4	2	1
0	1	0	1	0

= 10

Fill in the blanks

Convert 1101_2 to decimal

Binary value

16	8	4	2	1
0	1	1	0	1

= Answer _____

Convert 11011_2 to decimal

Binary value

16	8	4	2	1

= Answer _____

Answer:

1101 = 13

11011 = 27

If your answers are correct, please turn to page 14.

If your answers are incorrect, please read the explanation below and try again.

We use the same method as representing the binary number system. For example:

Convert 1101_2 to decimal.

Binary value

16	8	4	2	1
	1	1	0	1

$= (8\times1)+(4\times1)+(2\times0)+(1\times1)$

$= 8 + 4 + 0 + 1$

$= 13$

Convert 1111_2 to decimal.

Binary value

16	8	4	2	1
	1	1	1	1

= Answer _____

Answer

$1111_2 = 15$

(14)

GREAT! You are ready to practice your skill.

Turn to **page 15** and **answer all the questions.**

Then check your responses on pages 16 and 17.

PRACTICE

1. The binary number system requires only two digits: what would those two digits be?

Answer: ____ and ___

2. Using the binary value to write the number 16 in the binary number system.

Binary value	32	16	8	4	2	1

3. Convert the decimal 203 to binary, using the division rule.

4. Convert 11000_2 to decimal.

Answer:

1. The binary number system requires only the digits 0 and 1.

2.

Binary value					Decimal number		Binary number
16	8	4	2	1			
1	0	0	0	0	16	=	10000_2

3.

2)203		
101	remainder	1
2)101		
50	remainder	1
2) 50		
25	remainder	0
2) 25		
12	remainder	1
2) 12		
6	remainder	0
2) 6		
3	remainder	0
2) 3		
1	remainder	1
2) 1		
0	remainder	1

$203 = 11001011_2$

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